The hospital burden of critical illness across global settings: a point-prevalence and cohort study in Malawi, Sri Lanka and Sweden

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Key Points

Question: What is the burden of critical illness in hospitals in different global settings, and where are critically ill patients being cared for?

Findings: Among 3652 hospitalized patients in countries of different socio-economic levels we found a point-prevalence of critical illness of 12% with a hospital mortality of 19%. Of the critically ill patients 96% were cared for in general wards.

Meaning: Critical illness is common in hospitals and has a high mortality. Ensuring that feasible adequate critical care interventions are implemented throughout hospitals could impact a large number of high-risk patients and has potential to improve outcomes across all medical specialties.

Abstract

Importance: The burden of critical illness may have been underestimated and there is little data showing where critically ill patients receive care.

Objective: To assess the adult burden of critical illness across hospitals in different global settings.

Design, Setting, and Participants: This was a prospective, observational, hospital-based, point-prevalence and cohort study in Malawi, Sri Lanka and Sweden. On specific days, all adult in-patients in the eight study hospitals were examined by the study team for the presence of critical illness and followed up for hospital mortality.

Exposure: Patients with at least one severely deranged vital sign were classified as critically ill.

Main Outcomes and Measures: The primary study outcomes were the presence of critical illness and 30-day hospital mortality. In addition, we determined where in the hospitals the critically ill patients were being cared for and the association between critical illness and 30-day hospital mortality.

Results: Among 3652 hospitalized patients in countries of different socio-economic levels we found a point-prevalence of critical illness of 12.0% (95% CI, 11.0-13.1), with a hospital mortality of 18.7% (95% CI, 15.3-22.6). The crude odds ratio of death of critically ill compared to non-critically ill patients was 7.5 (95% CI, 5.4-10.2). Of the critically ill patients 96.1% (95% CI, 93.9-97.6) were cared for in the general wards outside Intensive Care Units (ICUs).

Conclusions and Relevance: The study has revealed a substantial burden of critical illness in hospitals from different global settings. One in eight hospital in-patients was critically ill, 19% of the critically ill died in hospital, and 96% of the critically ill patients were cared for outside of ICUs. Implementing fundamental low-cost critical care in units and general wards throughout hospitals could impact a large number of high-risk patients and has the potential to improve outcomes across all acute care specialties.

Introduction

Critical illness is as a 'state of ill health with vital organ dysfunction, a high risk of imminent death if care is not provided and the potential for reversibility.[1] Regardless of underlying diagnosis, critically ill patients require similar supportive actions to stabilize vital organ functions and prevent death. Such critical care[1] interventions are needed wherever a critically ill patient is located.[2] Although many effective critical care interventions are low-cost and feasible[4] there is alarming evidence from different settings that they are frequently not provided. [5-9] Improving care for critically ill patients could increase survival across all acute care specialties. [5,6,10-13]

There is limited evidence to inform policy makers, about the importance of critical illness and critical care. Priority decisions and investments in health care and research are often grounded in sources based on patients' diagnoses where information about critical illness is not captured.[14,15] Most research into critical illness is confined to Intensive Care Units (ICUs), where advanced and high-cost critical care is provided. ICUs are sparce in rural and low resource settings where critical care needs are high.[13,16-18] Per 100,000 population, ICU beds vary – from 0.1 in Malawi (low-income country), and 2.3 in Sri Lanka (middle-income country), to 5.8 in Sweden and 35 in the USA (high-income countries).[19-21]

It has been estimated that the global incidence of critical illness among adults is 30-45 million per year, based on extrapolation from a North American ICU registry.[22] This may be an underestimation as the adult incidence of sepsis alone is 24 million per year.[23] Additionally, there are indications that critically ill patients may often be cared for outside ICUs.[24-30] There is a need of data from critically ill patients throughout hospitals, across ward types, specialties and socioeconomic levels. In this multi-center global study, we aimed to assess the burden of critical illness among hospitalized adults.

Methods

Study design and settings

This was a prospective, observational, hospital-based, point-prevalence and cohort study in Malawi, Sri Lanka, and Sweden. The study countries were chosen to include a low-, a middle- and a high-income country. The annual health expenditure (USD) per capita ranges from 33 in Malawi, to 151 in Sri Lanka and 6915 in Sweden.[31] The study took place in eight public hospitals including primary and referral hospitals in each country **(Table 1).** The principles of Good Clinical Practice were followed. Ethical permissions were provided in all settings - Malawi: College of Medicine (P.08/16/2007); Sri Lanka: University of Kelaniya (P/111/04/2018) and University of Jaffna (J/ERC/19/102/NDR/0205); Sweden: Ethical Review Board Stockholm (2017-1907-31-1).

Table 1. Study countries and hospitals (Data from Hospital administrations and World Bank)

Country	Malawi		Sri Lanka		Sweden			
Population*	20,405,000		22,181,000		10,486,000			
GDP/capita* (USD)	645		3,354		56,424			
Life Expectancy (at birth) *	63		76		83			
Maternal mortality * (per 100,000 live births)	451		43		3			
Annual health expenditure per capita* (USD)	33		151		6915			
Hospital beds per 100,000 population*	130		420		210			
ICU beds per 100,000 population*	0.1		2.1		5.7			
Hospital	Queen Elizabeth Central Hospital	Chiradzulu District Hospital	Monaragala District General Hospital	Point Pedro Base Hospital	Örebro University Hospital	Mälar Hospital, Eskilstuna	Nyköpings Hospital	Kullbergska Hospital, Katrineholm
Hospital type	Government-run university hospital	Government-run primary hospital	Government-run secondary hospital	Government-run primary hospital	Government-run university hospital	Government-run secondary hospital	Government-run primary hospital	Government-run primary hospital
Immediate (extended) catchment population† (n)	1,000,000 (9,000,000)	240,000	556,000	150,000 (175,000)	200,000	146,000	96,000	59,000
Total Adult Hospital beds† (n)	1,150	240	460	221	402	254	122	57
ICU Beds† (n)	8	0	6	0	14	8	6	0
Admissions per year† (n)	40,000	10,000	48,000	24,448	29,000	18,821	10,823	4,250
Mean length of stay adult† (days)	±	2†	2†	2†	4,4†	4.6†	4.2†	4.6†
Hospital mortality per admission†	7%†	15%†	±	0.6%†	3.8%†	3.6%†	3.1%†	3.9%†

Characteristics of study countries and hospitals. The numbers in the table are not based on the study cohort. Data sources: *) World Bank Open Data 2024 †) Administrative data from study hospital. ±) Data unavailable
Abbreviations: GDP; Gross Domestic Product ICU; Intensive care unit; USD, United States Dollar

Participants and outcomes

In each hospital on the days of point-prevalence assessment, all patients in the wards above 18 years of age were included in the study. Participants who were able to, provided informed consent. For the

validity of the study, we included patients with reduced consciousness in absence of objection from the patient (verbal or non-verbal) or from the next of kin. We could not include patients who were in operating theaters or were absent and could not be found later in the day. The study excluded patients who were not admitted to hospital (neither had stayed, nor planned to stay overnight), women in active labor, patients with a psychiatric reason for admission, and moribund patients identified as *"dying"* by the attending nurse. All participants had their vital signs examined for presence of critical illness, and they were followed up for hospital mortality, censored at 30 days. We used the term *burden* of critical illness when referring to the impact of critical illness - both occurrence (prevalence) and consequence (mortality). The primary study outcomes were the point-prevalence of critical illness and the 30-day hospital mortality of patients with critical illness. In addition, we determined where in hospitals critically ill patients were cared for and the association between critical illness and 30-day hospital mortality.

Variables

Critical illness was defined as *"a state of ill health with vital organ dysfunction, a high risk of imminent death if care is not provided and a potential for reversibility"* [1] and operationalized by classifying a critically ill patient as someone with one or more severely deranged vital sign at the point prevalence examination. Such criteria are independent of ward type and specialty and are pragmatic for use in clinical practice. The parameters and *a priori* decided cutoffs for severely deranged vital signs are based on "danger signs" that are triggers for clinical intervention used at Karolinska University Hospital (Sweden) and in Muhimbili National Hospital (Tanzania) **(Table 2).**[27,30,32,33]

Table 2. Parameters and cutoffs for severely deranged vital signs - danger signs

		Danger Signs
A	**Airway sounds**	Stridor or Gurgling or Snoring
B	**Respiratory rate (per minute)**	<8 or >30
	Oxygen saturation (%)	<90
C	**Heart rate (per minute)**	<40 or >130
	Systolic blood pressure (mmHg)	<90
D	**Conscious level**	Glasgow Coma Scale <9

The patient's hospital records were used for clinical information about age, sex, specialty and decision to not resuscitate in case of cardiac arrest (DNR). ICU-beds were classified per hospital definition. All other patients were classified as located in general wards. Some hospitals described some ward beds as providing a higher care intensity termed "high care beds", or "high dependency unit" beds. However, the care and interventions available in such locations varied substantially between settings, which precluded a formal analysis.

Data collection

Data collections took place on individual days between 2017 and 2019 in the study hospitals. Each hospital was assessed at least twice to control for seasonal variation. All hospital wards and units were visited, regardless of admitting specialty. Teams of nurses and students of health care professions went from ward to ward to include all the hospital in-patients and assess their vital signs. A senior health professional or researcher supervised in each ward to ensure quality data collection. Prior to this, all data collectors had training and practice on research methods, ethics, study methods, equipment usage, and standardized vital signs assessments. The equipment were quality tested before each data collection and included automatic blood-pressure monitors, pulse oximeters, and clocks. Abnormal vital signs were re-checked, and alternative methods were used if a vital sign could not be assessed (e.g. using manual blood pressure measurement). The nurse-in-charge of the ward was notified immediately when a patient was identified as critically ill. The research team offered to document all vital signs for use in patient care.

We used field validated case report forms (CRF) in all settings. Paper-CRFs and double date entry into the database were used in Malawi and Sweden. In Sri Lanka, we used electronic CRFs on handheld tablets that subsequently fed into the database. In Malawi and Sri Lanka, the clinical background information was extracted from the paper-based patient records and outcomes were collected through follow-up of records and hospital administrative data. In Sweden, these data were collected from the electronic medical records.

Statistical methods

We used percentages to present point-prevalence, hospital mortality, and location of the critically ill. The association of critical illness and hospital mortality was assessed using odds ratios (OR) in crude logistic regression models and adjusted odds ratios (aOR) in models including prespecified potential confounders: age, sex and country. Missing data for a single vital sign were classified as not being a danger sign (the most common value), enabling use of the other vital signs to classify the patient's critical illness status. Participants who were lost to follow up or had missing data for age, sex or country were excluded from analyses. A 95% confidence interval (CI) was used in reporting findings. Stata SE 16.1 (Stata Corp, College Station, TX) was used for statistical analyses.

Results

A total of 3,682 participants were included initially. A final cohort of 3,652 participants was used for analyses, after exclusion of twenty patients who were lost to follow-up (18 from Malawi and 2 from Sri Lanka) and ten patients from Malawi with missing data for age. Out of 21,912 expected data points for vital signs (6 per participant), 56 (0.3%) were missing.

Women comprised 2,015 (55%) of all participants and 224 (51%) of the critically ill. The median age of the cohort was 58 years [IQR 34-75] and 61 years [IQR 37-76] among critically ill patients. The majority of patients were admitted to a medical ward: 1,846 (51%) of all patients and 327 (74%) of the critically ill.

In the study countries, there were 653 (59%) women in Malawi, 436 (60%) in Sri Lanka, and 926 (51%) in Sweden. The median age was 35 years [IQR 26-49] in Malawi, 41 years [IQR 30-62] in Sri Lanka and 73 years [IQR 61-82] Sweden. There were two patients (0.2%) with a DNR order in Malawi, none in Sri Lanka and 346 (19%) in Sweden. Clinical characteristics of the cohort are presented in **Table 3**.

Table 3. Participant characteristics

	ALL SETTINGS		MALAWI		SRI LANKA		SWEDEN	
	All	Critical	All	Critical	All	Critical	All	Critical
Participants, n	3652	439	1107	204	723	43	1822	192
Death in hospital, n (%)	178(4.9%)	82(19%)	85(7.1%)	42(21%)	8(1.1%)	6(14%)	85(4.7%)	34(18%)
Female, n (%)	2015(55%)	224(51%)	653(59%)	119(58%)	436(60%)	17(40%)	926(51%)	88(46%)
Age, years [IQR]	58[34-75]	61[37-76]	35[26-49]	38[30-51]	41[30-62]	56[39-68]	73[61-82]	76[69-86]
Specialty, n (% per column)								
- Medicine	1846(51%)	327(74%)	461(42%)	143(70%)	244(34%)	24(56%)	1141(62%)	160(83%)
- OBG	653(18%)	24(5.5%)	283(26%)	16(7.8%)	260(36%)	7(16%)	110(6.0%)	1(0.5%)
- Surgery	1151(31%)	87(20%)	362(33%)	45(22%)	218(30%)	11(26%)	571(31%)	31(16%)
- Unknown	2(<.1%)	1(<.1%)	1(<.1%)	0	1(<.1%)	1(2.3%)	0	0
DNR, n (% per column)	348(10%)	81(18%)	2(0.2%)	2(1%)	0	0	346(19%)	79(41%)
Level of care, n (% per column)								
- ICU	52(1.4%)	17 (3.9%)	5(0.5%)	3(1.5%)	7(1.0%)	3(7.0%)	40(2.2%)	11(5.7%)
- General Ward	3600(99%)	422(96%)	1102(99%)	201(99%)	716(99%)	40(93%)	1782(98%)	181(94%)

Abbreviations: DNR, Decision to Not Resuscitate in case of cardiac arrest; ICU, Intensive Care Unit; IQR, Inter Quartile Range; OBG, Obstetrics and Gynecology.

Critical illness was present in 439 patients, corresponding to a point-prevalence of critical illness of 12.0% (95% CI 11.0-13.1). The critically ill patients had a hospital mortality of 18.7% (15.5-22.8). Of the critically ill patients 96.1(95% CI 93.9-97.6) were cared for in a general ward. Outcome data are presented in **Table 4.**

Table 4. Critical illness: point-prevalence, mortality, and proportion in ICU

	All	Malawi	Sri Lanka	Sweden
Prevalence Critical Illness, % (95% CI)	12.0 (11.0-13.1)	18.4(16.3-20.1)	5.9 (4.4-7.9)	10.5 (9.2-12.0)
Mortality Critical Illness, % (95% CI)	18.7 (15.3-22.6)	20.6 (15.6-26.7)	14.0 (6.3-28.3)	17.7 (12.9-23.8)
Location of critically ill patients, % (95% CI)				
- **ICU**	3.9 (2.4-6.1)	1.5 (0.5-4.5)	7.0 (2.2-20.1)	5.7 (3.2-10.1)
- **General Ward**	96.1(93.9-97.6)	98.5(95.5-99.5)	93.0 (79.9-97.8)	94.3(89.9-96.8)

Abbreviations: CI, confidence interval; ICU, Intensive Care Unit

In the whole cohort, the association between critical illness and death was OR 7.5 (5.4-10.2). In the model adjusted for age and sex, aOR was 7.3 (5.3-10.0). In the model adjusted for age, sex and country, aOR was 6.1 (4.4-8.4). The use of cubic splines to ensure that the association between age and death was not underestimated did not increase the association in any model and so was not used. **(Table 5)**

Table 5. The association between critical illness and 30-day hospital mortality

	All	Malawi	Sri Lanka	Sweden
Crude models				
Critical illness, OR (95%CI)	**7.5 (5.4-10.2)**	**5.2 (3.3-8.2)**	**53.9 (9.3-564)**	**6.7 (4.2-10.6)**
Adjusted models				
Critical illness, aOR (95%CI)	**7.3 (5.3-10.0)**	**5.3 (3.5-8.5)**	**41.1 (7.8-217)**	**5.5 (3.4-8.8)**
Age (one year), aOR (95%CI)	1.01 (1.00-1.02)	1.01 (0.99-1.02)	1.02 (0.98-1.06)	1.04 (1.02-1.06)
Sex (male), aOR (95%CI)	2.0 (1.4-2.7)	2.7 (1.7-4.4)	2.5 (0.5-14)	1.6 (0.9-2.5)
Critical illness aOR (95%CI)	**6.1 (4.4-8.4)**			
Age, (one year), aOR (95%CI)	1.02 (1.01-1.03)			
Sex, (male), aOR (95%CI)	2.0 (1.5-2.8)			
Country, aOR (95%CI)				
- Malawi	6.8 (3.2-14.4)			
- Sweden	2.4 (1.1-5.2)			
- Sri Lanka	1 (reference)			

Abbreviations: aOR, adjusted Odds Ratio; OR Odds Ratio; CI, Confidence Interval

Discussion

In this prospective point prevalence and cohort study of all in-patients in eight hospitals from Malawi, Sri Lanka and Sweden, we found a substantial burden of critical illness. The point-prevalence of critical illness was 12% and the critically ill patients had a hospital mortality of 19%. A large majority of the critically ill patients, 96%, were cared for in general wards outside of the ICUs.

The point-prevalence of critical illness is consistent with data that could be extracted from single-center studies with other aims. Among hospital patients in Finland and Sweden, 8% and 12-14% respectively had a severely deranged vital sign.[25-27] In medical and surgical wards in Uganda, 12% of patients had a "critical" modified early waring score (MEWS) of more than 5. [28] Our results support previous indications of a substantial burden of critical illness in different global contexts.[22]

The mortality of critically ill patients found is high compared to other patient groups and diagnoses of public interest. For example, patients admitted for care in Swedish ICUs had a hospital mortality of 14%.[34] Among patients with COVID-19 during the severe first wave of the pandemic in USA in 2020, 20% died in hospital.[35] Admitted patients with acute myocardial infarction with ST-elevation in Sub-Saharan Africa, South Asia and North Europe had 30-day mortalities of 2.4-5.0%, 1.0% and 0.4% respectively.[28-30] Our findings confirm that critical illness, as identified in a pragmatic way using deranged vital signs, is a high-risk condition.

Most critically ill patients were cared for in general wards outside ICUs. As countries have such large differences in the number of ICU beds – 350 times more beds per 100,000 population in the USA than in Malawi[21] – the presence of critically ill patients in general wards might be assumed to be specific to low-income countries. This is neither supported by our results nor by previous research.[25-27,29]

There are likely explanations behind specific findings in each of the study countries. Sri Lanka, the middle-income country, had the lowest prevalence and mortality of critical illness. But it had also the lowest mortality of non-critically ill patients (0.3%) - explaining the high OR for critical illness in Sri Lanka. One reason behind this may be a higher number of hospital beds (420) per 100,000 population than Sweden (210) and Malawi (130).[31] This could lead to a lower threshold for admitting patients to hospitals in Sri Lanka than the other countries, thus" diluting" the proportion of critically ill patients. It was not surprising that the highest critical illness mortality would be found for the patients in Malawi (21%) where resources are far scarcer than in the other countries, affecting both the determinants of health and the budget for health care.[31] In low-income countries, critical illness may also be common outside hospital, since limited access to health facilities may delay or preclude care.[36] The high mortality of critically ill patients in Sweden (18%) was an interesting finding, and is likely explained by the high median age of the patients (73 years). Frailty, multimorbidity and death are more common in older individuals.[37] It should be noted that most patients with a DNR in Sweden receive active treatments for their acute illness, such as pneumonia or hip fracture so they were included in analyses. Conversely, moribund patients were excluded from the study.

Implications

The findings indicate the importance of health systems recognizing and prioritizing critical illness throughout in-hospital services, units and wards. This is an achievable aim and in fact, critical care for most critically ill patients[5-9] can be provided outside ICUs.[4,11,13,38] The recently defined Essential Emergency and Critical Care (EECC) describes this care, and includes 40 foundational interventions selected for clinical effectiveness and feasibility in all hospital settings such as triage, airway protection and oxygen therapy.[3,12] EECC aligns with WHO's Fair Priorities framework to maximize the population impact of care interventions.[39] Such ward-based critical care has lower costs and has been shown to be more cost-effective than ICU care for many patients groups.[40-43] In Tanzania, EECC has

been estimated to be highly cost-effective at 14 USD per healthy life-year gained.[44] Ensuring EECC is provided to all patients who need it throughout hospitals and health systems could be the rational first step when improving critical care services.[11] In cases where such fundamental critical care is not enough to stabilize organ functions, high dependency units (HDUs) may be a reasonable subsequent step and may be more equitable and effective than an expansion of resource-intensive ICUs.[45,46] Governments and health organizations that use a strategy to improve critical care of starting from the fundamental level and building up from there could reach all critically ill patients, be cost-effective, and maximize impact at population level.[10,11,47]

Strengths and limitations

The prospective examination of all in-patients in this study, regardless of diagnosis and location in hospital, minimized the risk for selection bias and misclassification. The quality of the data collection increased internal validity through high inclusion rates, accuracy of the data and few missing data points. Studying hospitals in a low-, a middle- and a high-income country enabled the inclusion of patients from settings with a large global variation. The feasible clinical criteria for identification of critical illness and the pragmatic data collection methods that were used enable replication in health facility audits and larger studies.

The study has limitations. First, the pragmatic criteria for critical illness may have missed high-risk patients whose vital signs were insufficiently deranged or who had been stabilized by healthcare interventions. Conversely, some patients with adapted physiology due to chronic disease may have been misclassified as critically ill. Second, we could not include patients in operating theatres, some of whom may have been critically ill. Third, data were collected during working hours and the burden of critical illness may be different in weekends and nights.[48] Fourth, the ethical imperative to inform the ward nurses about the patients who were critically ill may have led to improved care and reduced critical illness mortality of the study cohort. Last, the limited number of countries and hospitals included limits generalization, but we do not have reason to think that the burden of critical illness would be markedly different in other hospitals.

Conclusion

The study has revealed a substantial burden of critical illness in hospitals from different global settings. One in eight hospital in-patients was critically ill, 19% of the critically ill died in hospital, and 96% of the critically ill patients were cared for in general wards outside of ICUs. Implementing feasible, low-cost, critical care in general wards and units throughout hospitals would impact a large number of high-risk patients and has the potential to improve outcomes across all acute care specialties.

ABBREVIATIONS

aOR	Adjusted Odds Ratio
CI	Confidence Interval
CRF	Case Report Form
DNR	Decision to Not Resuscitate in case of cardiac arrest
EECC	Essential Emergency and Critical Care
GDP	Gross Domestic Product
HDU	High Dependency Unit
ICU	Intensive Care Unit
IQR	Inter Quartile Range
OBG	Obstetrics and Gynecology
OR	Odds Ratio
USA	United States of America
USD	United States Dollar

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